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$\therefore PQ$  and  $GO$  bisect one another at  $M$ . From the triangles  $MQO$  and  $GPM$ ,  $GM=OM$ ,  $PM=QM$ ,  $\angle OMQ=\angle PMG$ .  $\therefore OQ=PG=FP$ , and  $OQ$  is also parallel to  $FP$ .  $\therefore OF=PQ$ .

$\therefore$  The radius of  $EFD$ =the diameter of  $ABC$ . Perpendicular to  $FG$  at the point  $P$  draw  $PO'=QD$ . Then since  $FP=PG=OQ$ ,  $O'F=O'G=OD$ .

$$\therefore OF=O'F=OD=O'D=O'G.$$

$\therefore$  radius of  $FGD$ =radius  $EFD$ =diameter  $ABC$ .

Similarly radius  $EGD$  and radius  $EGF$ =radius (each)  $EFD$ .

98. Proposed by EDWARD R. ROBBINS, Master in Mathematics and Physics, Lawrenceville School, Lawrenceville, N. J.

Construct a circle which shall pass through two given points and touch a given circle, (1) when the distance between the points is less than the diameter of the circle, and (2) when it is greater.

I. Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Mathematics and Science, Chester High School, Chester, Pa.

The construction for both cases is the same.

I Case. Let  $A, B$  be the given points,  $CMDK$  the given circle. Through  $A, B$  draw the circle  $ABEF$  intersecting the given circle in  $E, F$ . Draw  $AB$ ,  $EF$  intersecting at  $G$ . Draw the tangents  $GK, GM$ . Draw  $QQ_1$  perpendicular to  $AB$  at its mid-point. Through  $R$ , the center of  $CMDK$ , draw  $RM, RK$  intersecting  $QQ_1$  in  $O_1, O$ . Then  $O, O_1$  are the centers of two circles satisfying the conditions, and  $ABK, ABM$  are the circles.

II Case. Let  $C, D$  be the given points,  $AHBL$  the given circle. Through  $C, D$  describe the circle  $CDEF$  intersecting the given circle in  $E, F$ . Draw  $CD$ ,  $EF$  intersecting at  $G$ . Draw the tangents  $GH, GL$ . Draw  $RR_1$  perpendicular to  $CD$  at its mid-point. Through  $Q$ , the center of  $AHBL$ , draw  $QL, QH$  intersecting  $RR_1$  in  $P, P_1$ . Then  $P, P_1$  are the centers of two circles satisfying the conditions, and  $CDL, CDH$  are the circles.

In the above both points are without the given circle. This problem is thoroughly discussed on page 271, No. 8, Vol. I., THE AMERICAN MATHEMATICAL MONTHLY.

II. Solution by FREDERIC R. HONEY, Ph. B., New Haven, Conn.

The following description applies when the distance between the points is less, and when greater than the diameter of the circle.

Let  $a$  and  $b$  be the given points and  $A$  the circumference of the given circle.

Through  $a$  and  $b$  pass a circle the circumference of which intersects  $A$  at  $c$  and  $d$ . Draw  $ba$  and  $dc$  and produce these lines until they meet at  $e$ . Draw  $ef$  tangent to  $A$ . Through the point of tangency  $f$  and the given points  $a$  and  $b$  pass the required circle  $C$ . Since two tangents may be drawn there are, in each case, two solutions.

Analysis of the construction:  $eb \times ea = ed \times ec = (ef)^2$ .

[NOTE. For a demonstration of this same proposition with a diagram, see Vol. I., page 271. Professors Zerr and Honey each furnished neat diagrams with these demonstrations, but we believe the demonstrations sufficiently clear without them. Ed. F.]